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LVI. A MODIFICATION OF THE DEFLECTION BALANCE FOR USE IN BIOCHEMICAL LABORATORIES.

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The instrument to be described was evolved for the purpose of weighing out small quantities of reagents of the order of 10 mg. more rapidly than is possible on an ordinary chemical balance. It has proved very easy to use and may find other uses. It can replace the torsion balance of any range and costs approximately £2. 10*s*. 0*d*. to make. Similar deflection balances have been used before [Salvioli, 1919; Research staff of G.E.C., 1923]. Salvioli used glass fibres, which are too fragile for common use, and observed the deflection with a microscope. The G.E.C. instrument has a steel wire but no scale pan and the deflection is observed by projection. The microscope (or projection system) has been replaced in the instrument to be described by a simple magnifying glass and the glass fibre by a steel wire which can be quite roughly handled without altering its calibration value.

The base of the balance consists of a wooden block *A* mounted on tripod screws *P*. Fastened to the top of this is a brass plate *L*, which, to ensure rigidity, is attached by eight screws. On top of this at one end is attached the brass or wooden block *J*, and fastened to the top of this is a brass or steel block *K'* with a longitudinal V-shaped groove in its upper surface. *K* is another similar block, with a groove on its lower surface, which is held on by the knurled nuts *M*. A small brass rod *R* is held between *K* and *K'*, and to the end of this rod is soldered a tinned steel wire *B*, 0·039 mm. in diameter. The other end of this wire is bent downwards as in the figure and is rounded off on a hone. The deflection of this wire is used as the index of the weight of material placed in the scale pan *E*, the position of which is fixed in relation to the wire by bending the wire *B* into the hook shown in the figure. The scale pan (see Fig. 1 *d*) is made of a thin piece of mica *F*, square in shape, to which is attached, by means of Chatterton compound, the fine (40 gauge) copper wire *G* bent into a hook which rests on the hook on the wire *B*. The weight of the pan is about 18 mg. On one occasion, a very dry frosty day, the pan and the slip of mica carrying the powder to be weighed were found to become electrified by friction, and to be difficult, for that reason, to manipulate. This difficulty was overcome by gently breathing on the mica in order to render the surface an electrical conductor[1], or the pan may be covered with a thin deposit of platinum by immersing it in 1 % H_2 $PtCl_6$ in bergamot oil and heating slowly to just below redness. The wire and pan are covered with a glass hood in a metal frame *I* hinged at *C*.

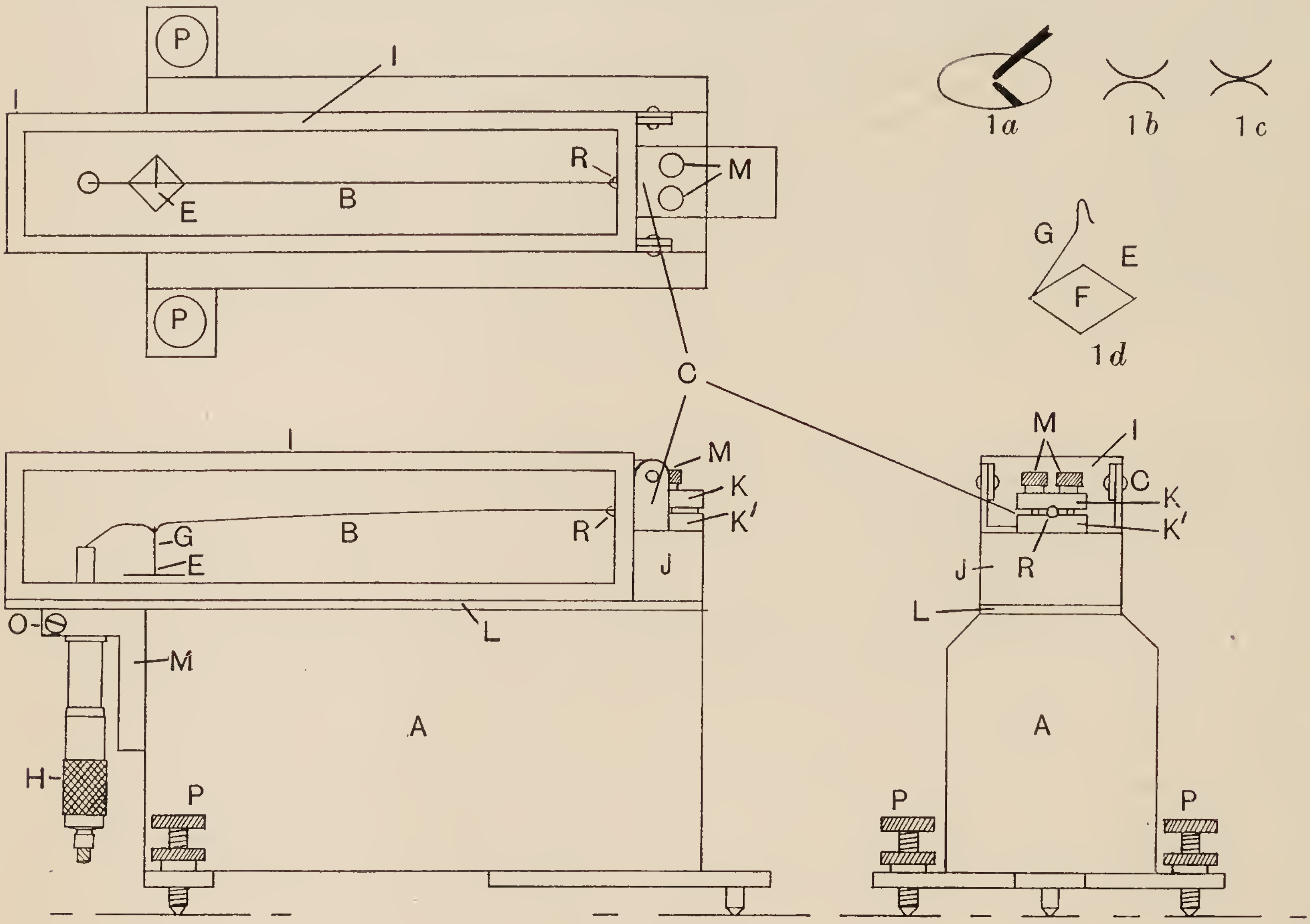

Fig. 1.

The object to be weighed is placed on this pan, powders being weighed on a separate piece of mica placed on the pan. The excess of weight causes a deflection of the wire *B*, which is measured by the micrometer head *H* mounted in the angle block *N* and passing through a hole in the brass plate *L* (Starrett micrometer head obtainable at engineers' tool-shops). The zero reading is first obtained with the pan empty. The micrometer is then screwed up until the end of the micrometer plunger just touches the wire, contact being observed through a lens magnifying seven times. The actual point of contact can be decided with great accuracy because there is a reflected image of the end of the wire in the upper surface of the micrometer plunger (Fig. 1 *a*). The wire is rounded off and rests tangentially on the plunger as in the diagram. If a lamp is placed behind and a little to the left of the micrometer the disappearance of the fine line of light between the image and the wire enables the position of the wire to be determined with an accuracy of 0·001 mm. Just before contact occurs the wire and its image are separated by a fine line of light as in Fig. 1 *b*. At the moment of contact the fine white line is apparently replaced by a fairly broad surface of contact the shape of which is represented in Fig. 1 *c*. This method of measuring small lengths is, of course, not new, but is generally used with a pool of mercury as a mirror. The setting up of the wire so as to give a deflection of any convenient value is carried out in the following manner.

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[1] The procedure described for the removal of an electrical charge by breathing on the pan is not so unsound as it might appear. The amount of moisture condensing on the pan is quite beyond the range of detection by weighing although sufficient to dissipate the charge.

A wire is chosen of about the dimensions required and one end bent down and rounded off. A hole is drilled along the long axis of a piece of brass rod *R*, 1 inch long by 3/16 inch diameter, of such a size as to be a sliding fit for the straight end of the wire. The rod is then clamped between the flat pieces of steel *K* and *K′* by knurled nuts *M* and a point on the wire found where the application of a 10 mg. rider deflects the bent end of the wire 1 millimetre. A hook is then made as nearly as possible at this point and the wire slid in or out of the brass rod *R* until the deflection produced by 10 mg. is exactly 1 mm. again. The wire is then fixed to the rod by solder. The degree of accuracy obtainable is illustrated by the tables. These represent an average of 3–5 readings at each point, and the worst agreement amongst the series of readings is shown below, Table II.

Table I.

Total load in pan (weight of pan 18 mg.)	Deflection: mm. for 10 mg.
10 mg.	1·00125
30 ,,	1·006
50 ,,	0·9977

The same 10 mg. rider was added (column 2) at each stage, other weights (column 1) being made up from a box of weights, and the readings in the second column represent the increment at each load produced by the addition of this rider.

Table II.

Total load on pan	Deflection in mm. on addition of a reputed 1 mg. weight
1	0·101
11	0·1014
16	0·1015
31	0·1007
41	0·104

This "1 mg." weight is obviously rather more than $\frac{1}{10}$ of the weight of the 10 mg. rider used for the first table. The worst agreement obtained amongst readings of any of the above points was at a load of 40 mg. and the readings were:

8·582, 8·583, 8·585, 8·584, 8·585 mm.

In weighing, the substance is placed either directly on the pan or on a thin flake of mica which is placed on the pan. It will be seen that up to a total load of between 30 and 40 mg. the readings are proportional to the weight with an accuracy of ± 0·01 mg. The calibration can be made to depend on one 10 mg. rider and can be checked in a few seconds at any time. The deflection for 10 mg. has remained constant for 8 months, and readings for the same rider never differ by more than 0·01 mg.

The apparatus is covered with a glass hood *I* to keep off draughts and dust, the reading being made through the glass. The top of the micrometer and the wire need dusting with a camel hair brush occasionally and should be gently polished with metal polish to prevent sticking. A series of wires of different thicknesses of ranges 0·1 to 1, 1 to 10, 10 to 100, and 100 to 1000 mg. can be made and used in the same instrument.

SUMMARY.

A cheap and simple form of balance is described, the action of which depends on the bending of a steel wire. By its means 1 to 30 mg. can be weighed to ± 0·01 mg. in 30 seconds. By using a series of wires of different thicknesses on the same instrument, the replacement of the wire by another taking only a few seconds, any range of weights from 1 mg. to 1 g. can be weighed with an accuracy of ± 1 in 10,000.

I take this opportunity of thanking my mechanic, F. Gowlett, for his assistance.

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